

NOAA Space Weather Prediction Testbed: Overview and Updates

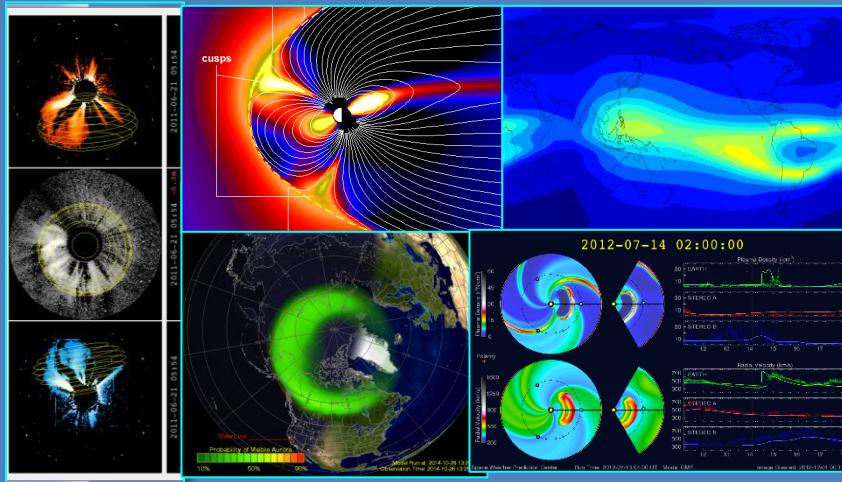
Rodney Viereck

*Director, Space Weather Prediction Testbed,
NOAA Space Weather Prediction Center*

Outline:
Overview
The Transition Process
Accomplishments and Goals

Space Weather Prediction Testbed

NOAA Space Weather R & D Transitioning models into operations



Research-to-Operations

- Applied Research
- Model Development
- Model Test/Evaluation
- Model Transition
- Operations Support

Operations-to-Research


- Customer Requirements
- Observation Requirements
- Research Requirements

Mission: Accelerate and improve the quantitative use of scientific research in space weather specification and prediction to improve forecasts, alerts, watches, warnings and products for customers.

NOAA Testbeds and Proving Grounds

- NOAA has 10 other testbeds and proving grounds.
- SWPT is unique...
 - Only space weather R&D in NOAA
 - No grants program (yet)
 - Broad range of projects
 - Model development
 - Satellite data processing
 - Data acquisition
 - Transition (R2O)
 - Etc...

beds.noaa.gov












 **NOAA** TESTBEDS & PROVING GROUNDS
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

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Welcome to the NOAA Testbed and Proving Ground Portal

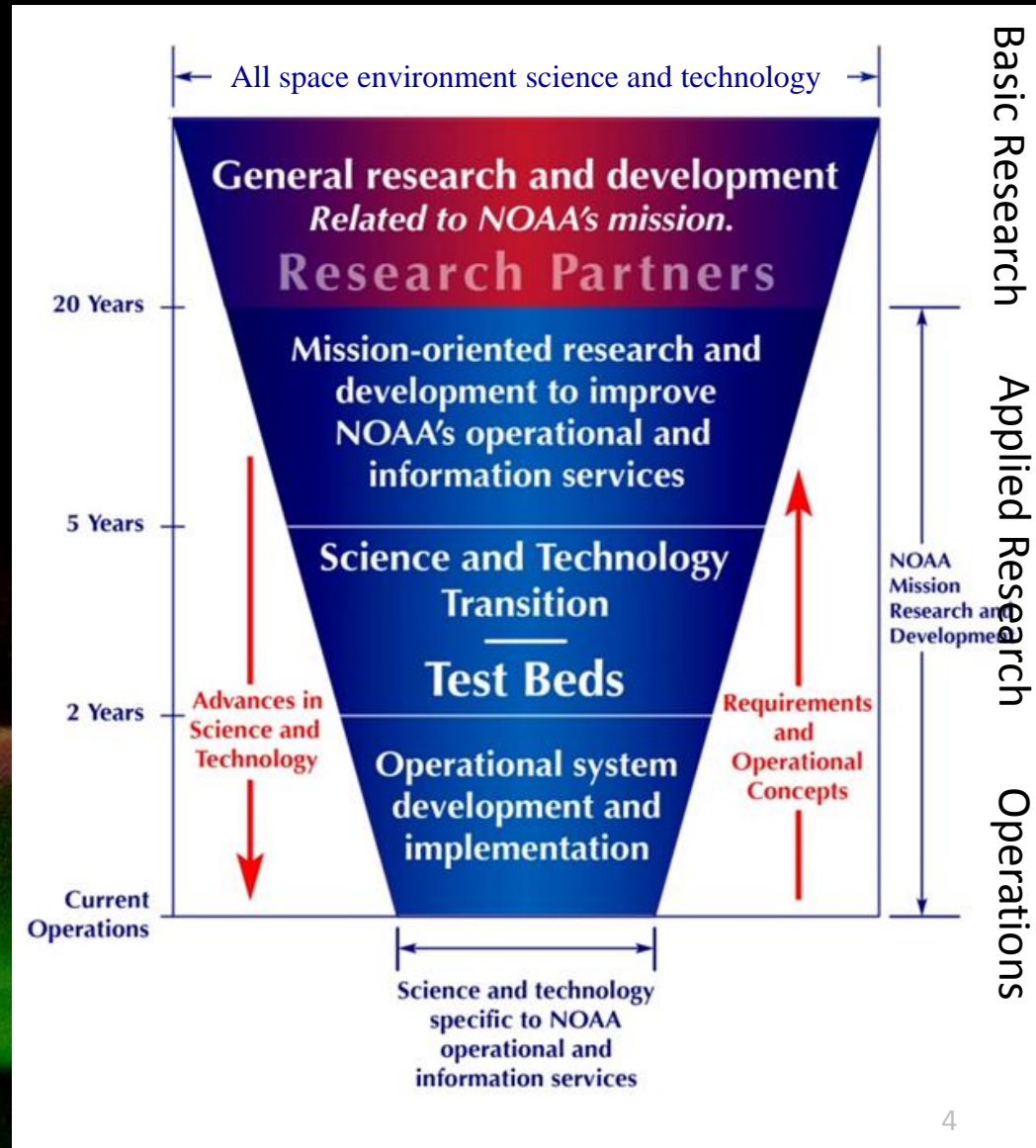
NOAA's testbeds and proving grounds facilitate the orderly transition of research capabilities to operational implementation through development testing in testbeds, and pre-deployment testing and operational readiness/suitability evaluation in operational proving grounds, as described in the approved [Guidelines](#) and [Performance Measures](#).

The NOAA Testbed and Operational Proving Ground [Coordinating Committee](#) provides a forum for effective and efficient functioning of NOAA's testbeds and proving grounds.

 Aviation Weather Testbed AWT tests new science and technology to produce better aviation weather products and services. (Charter)	 Climate Testbed CTB accelerates transition of scientific advances from the climate research community to improved NOAA climate forecast products and services. (Charter)	 Coastal & Ocean Modeling Testbed COMT accelerates transition of advances from the coastal and ocean modeling research community to improved operational ocean products and services. (Charter)
 Developmental Testbed Center DTC improves weather forecasts by facilitating transition of the most promising new NWP techniques from research into operations. (Charter)	 GOES-R Proving Ground GRPG tests and evaluates simulated GOES-R products before the GOES-R satellite is launched into space. (Charter)	 Hazardous Weather Testbed HWT accelerates transition of new meteorological insights and technologies into advances in forecasting and warning for hazardous weather events. (Charter)
 Hydrometeorology Testbed HMT conducts research on precipitation and weather conditions that can lead to flooding, and fosters transition of scientific advances and new tools into forecasting operations. (Charter)	 Joint Center for Satellite Data Assimilation JCSDA accelerates and improves use of research and operational satellite data in weather, ocean, climate and environmental analysis and prediction systems. (Charter)	 Joint Hurricane Testbed JHT is a competitive, peer-reviewed, granting process to choose the best mature research products for testing and transitioning to operations. Includes modeling, data gathering, and decision support components. (Charter)
 Operations Proving Ground OPG serves as a framework to advance NWS decision-support services and science & technology for a weather-ready nation. (Charter)	 Space Weather Prediction Testbed SWPT supports development and transition of new space weather models, products, and services. Infuses new research to improve accuracy, lead-time and value of products, forecasts, alerts, watches, and warnings. (Charter)	

The NOAA R&D Funnel

- The R2O process should enhance the transfer of scientific advances and technology into NOAA operational and information services.
- The R2O process requires significant multi-agency support beyond the research model development stage.

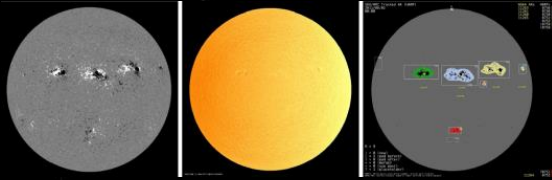


SWPT Staff

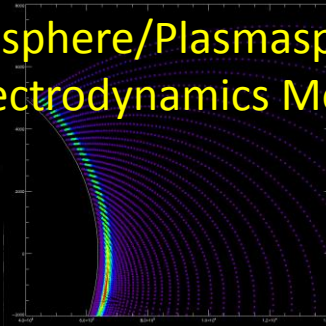
- 16 PhD scientists, 2 Developers, 2 Graduate students
 - Support: ~55% NOAA, ~35% NASA Grants, ~10% NSF/AFOSR Grants
 - Four supported 100% NOAA/NESDIS for DSCOV ground system
- Hiring soon (FY15)
 - Scientific Programmer: GS 13-14
 - Solar wind scientist programmer (CU/CIRES)
 - GONG transition and ADAPT implementation director (CU/CIRES)
- Hiring next year (FY16)
 - Ionospheric scientist programmer (CU/CIRES)
 - WAM scientific programmer (CU/CIRES)
 - Data assimilation developer (CU/CIRES)

Models Under Development

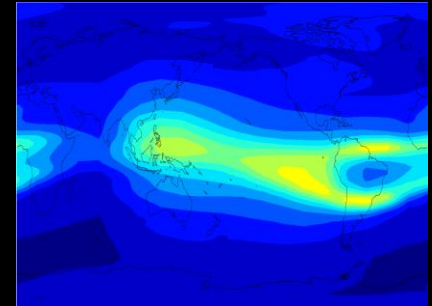
Solar Flare Forecast



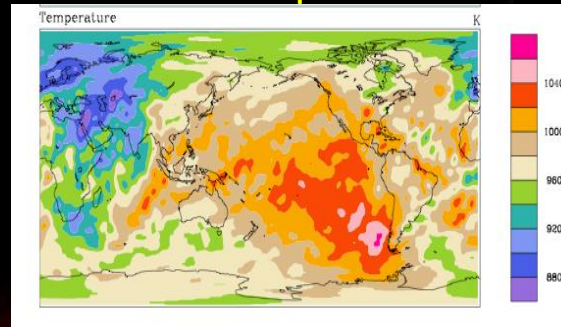
Ionosphere/Plasmasphere/ Electrodynamics Model



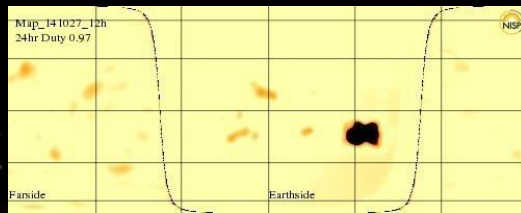
Global TEC Assimilative Model



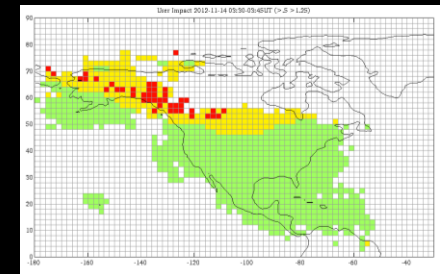
Whole Atmosphere Model



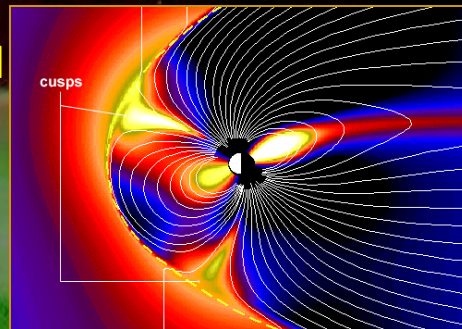
Far-side Analysis



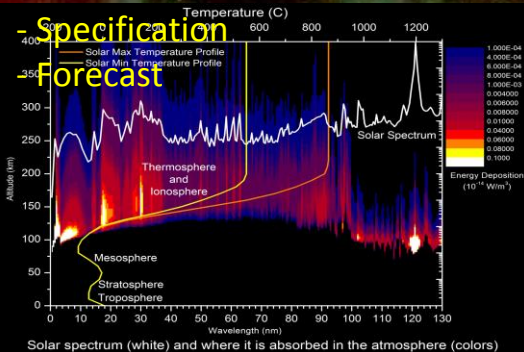
ROTI GPS Product



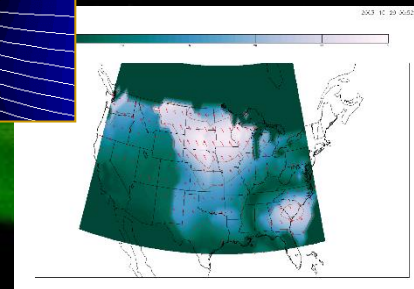
Geospace Model



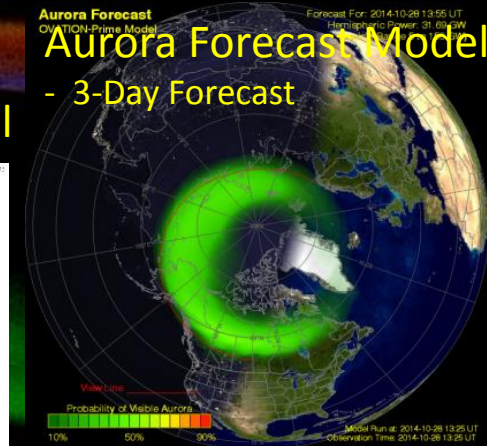
Solar EUV Irradiance Model



Electric Field Model

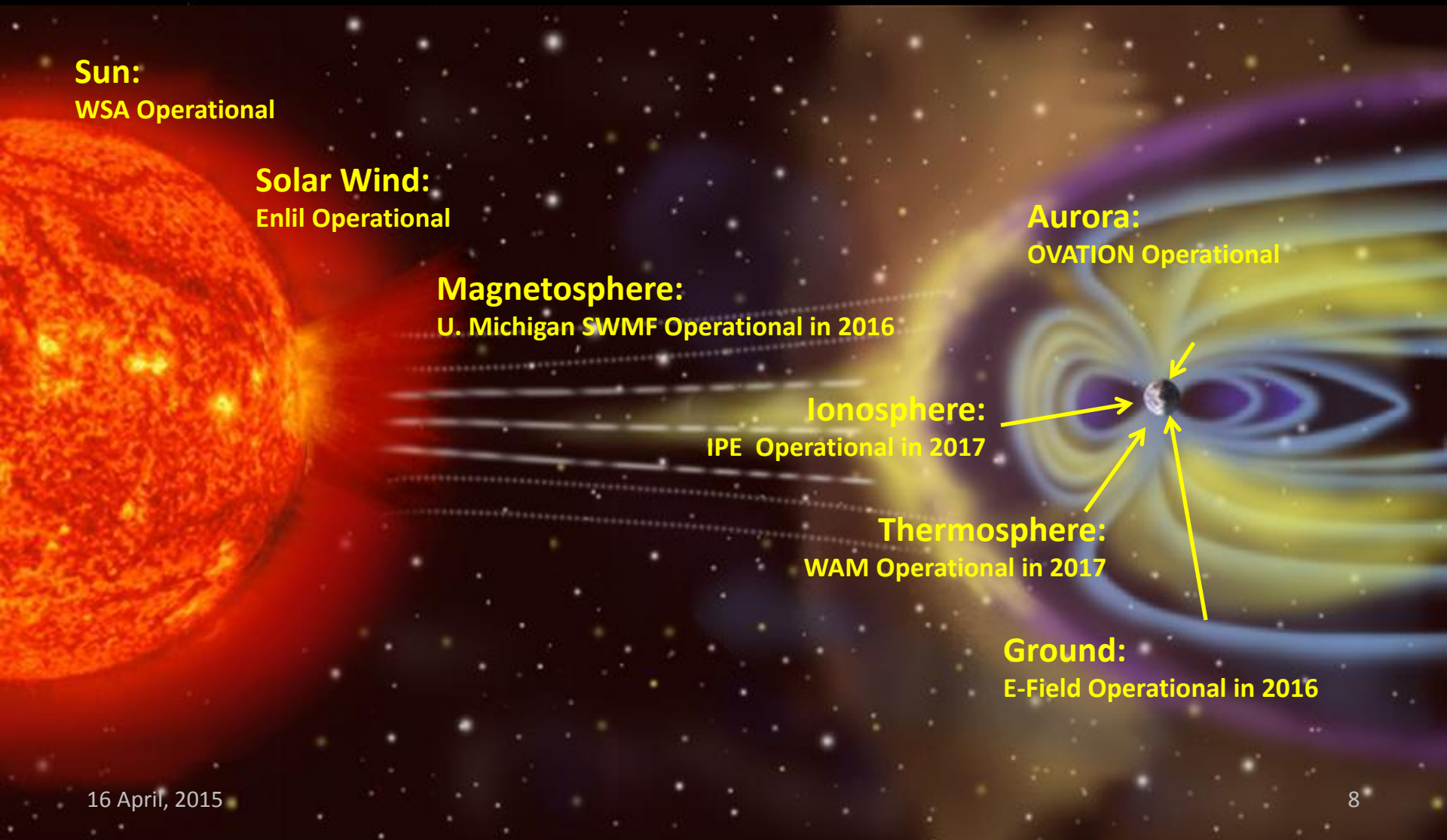


Aurora Forecast Model - 3-Day Forecast



16 April, 2015

Modeling at NOAA – A Sun to Earth Modeling Partnerships with the Space Weather Research Community



Modeling at NOAA – A Sun to Earth Modeling Partnerships with the Space Weather Research Community

Sun:

WSA
GONG Processing
Flare Prediction (SBIR)
Fareside Imaging (SBIR)
EUV Irradiance

Solar Wind:

Enlil
DSCOVR
L1-Earth Transit

Magnetosphere:

U. Michigan SWMF
GOES Magnetopause Model

Ionosphere:

IPE
US-TEC
NA-TEC
Global TEC
COSMIC II
Ground GPS Data
GOLD
ROTI (SBIR)
Equatorial Scintillation

Aurora:

30 Minute Forecast
3 Day Forecast

Thermosphere

WAM
CTIPe

Ground:

E-Field
Radiation

SWPT Projects

- WSA-Enlil
- Geospace
- IDEA
- GOES
- GONG
- ADAPT
- DSCOVR
- COSMIC II
- GOLD
- Ensemble modeling
- Data Assimilation
- Solar Cycle Prediction
- Ovation Aurora
- NA-TEC
- Global TEC
- SBIRs (ROTI, Flares, Fareside)
- Solar EUV Irradiance
- L1-Earth Transit
- Magnetopause Crossing
- Ground E-Field Specification
- Equatorial Scintillation

SWPT Projects

(Other talks/posters at this conference)

- WSA-Enlil
- Geospace
- IDEA
- GOES
- GONG
- ADAPT
- DSCOVR
- COSMIC II
- GOLD
- Ensemble modeling
- Data Assimilation
- Solar Cycle Prediction
- Ovation Aurora
- NA-TEC
- Global TEC
- SBIRs (ROTI, Flares, Fareside)
- Solar EUV Irradiance
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- Magnetopause Crossing
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- Equatorial Scintillation

Different Procedures for Project Selection and Development

- **Direct Approach:** Select model from the research community based on published works.
- **Democratic Approach:** Hold an open competition between modelers, brokered by a neutral third party (NASA).
- **SBIR:** Use the SBIR process to fund development of new models and products
- **In-House Approach:** Develop our own model from the ground up (usually with collaboration).

SWPT Projects

Direct Approach

- WSA-Enlil
- GONG
- ADAPT
- GOLD
- OVATION
- Ground E-Field Specification

Democratic

- Geospace
- Global TEC

SBIR

- ROTI
- Flare Forecast
- Fareside Imaging

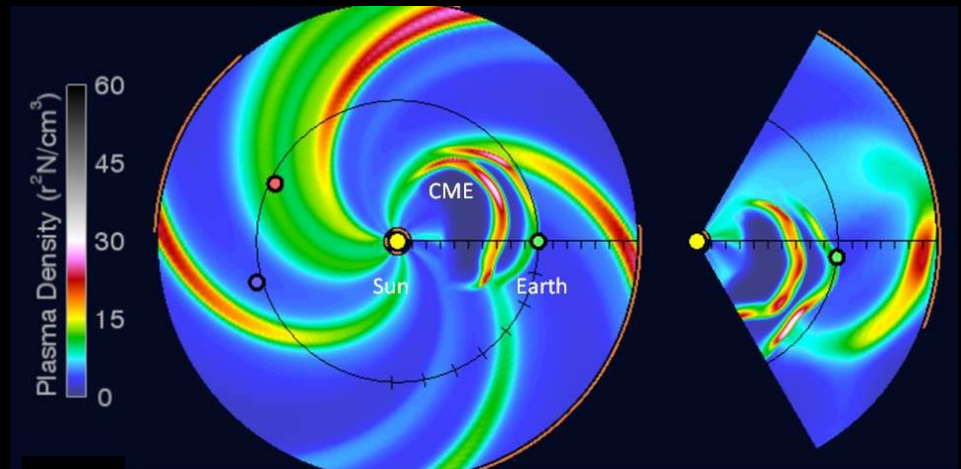
In-House

- IDEA
- NA-TEC
- L1-Earth Transit
- Magnetopause Crossing
- Equatorial Scintillation
- Ensemble modeling
- Data Assimilation
- Solar Cycle
- COSMIC II
- GOES

WSA-Enlil Model:

The Direct Approach to Model Transition

- Scientists were invited to work at SWPC
 - Learn the needs and requirements first hand
 - Improve geomagnetic storm forecasts
- Upgrade CME Analysis Tool
 - Improve CME parameterization
 - Include STEREO HI Data
 - Add Density Estimates
- Upgrade Enlil Model
- Upgrade WSA
- Incorporate ADAPT
- Explore ensemble modeling for improved forecast accuracy
 - Working with international partners who are also running WSA-Enlil operationally.
- Working with CCMC to validate the performance of the WSA – Enlil upgrades

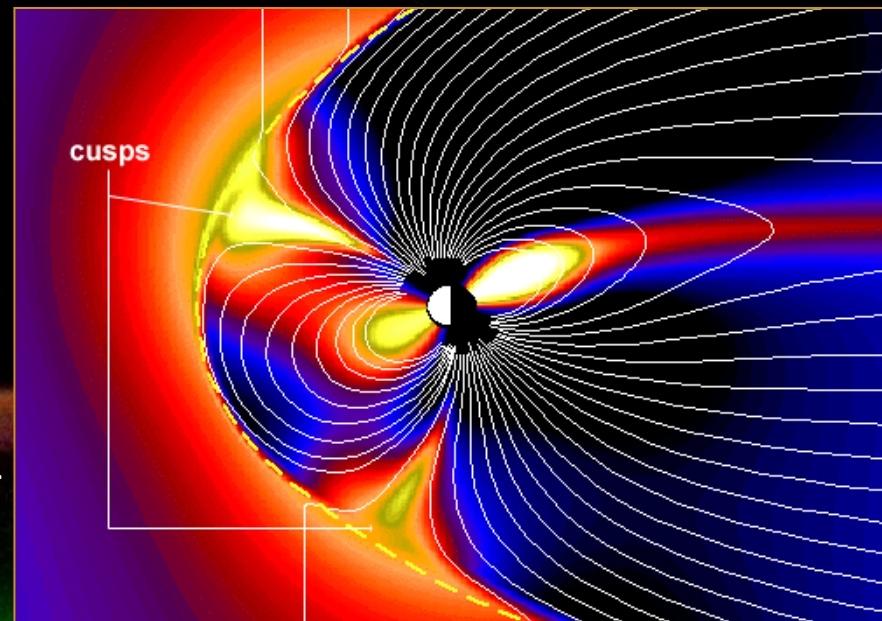


Note: To implement all of these improvements and upgrades, SWPC will need to hire someone to provide Operations and Maintenance (O&M) of WSA-Enlil.

Geospace Model:

The Democratic Approach to Model Transition

- Provide regional geomagnetic storm forecast for electric power industry
- The CCMC and SWPT evaluated 5 geospace models
 - Model attributes considered
 - Performance and Accuracy, Reliability, IT Resources, Maturity and Supportability
- Status:
 - University of Michigan Space Weather Modeling Framework (SWMF) was selected for transition to operations
 - SWMF Currently running in test-mode at NCEP
 - Operational procedures, data flow, products, etc... are being developed
- Working with CCMC to perform parameter studies to determine the optimum spatial and temporal model resolution
- FY15Q4: U.M geospace model will be ready for transition at NCEP.
- **See talk on Friday by George Millward**



Note: Once the SWMF model has been transitioned into operations, SWPC will need to hire someone to provide O&M

Integrated Dynamics in Earth's Atmosphere (IDEA)

In-House Development and Transition

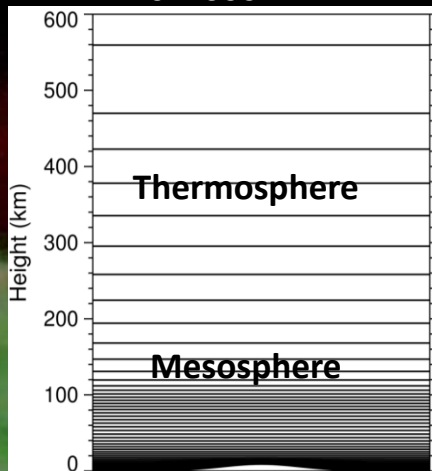
Whole Atmosphere Model (WAM = Extended GFS)

Ionosphere Plasmasphere Electrodynamics (IPE)

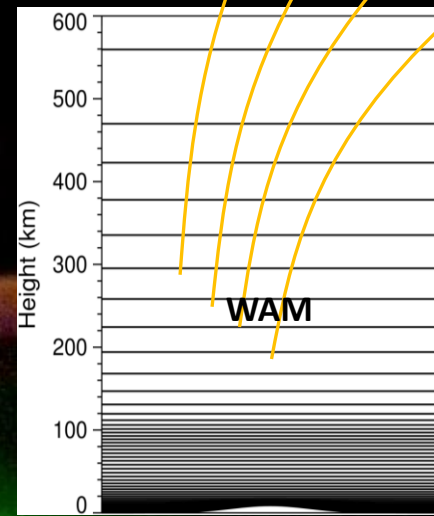
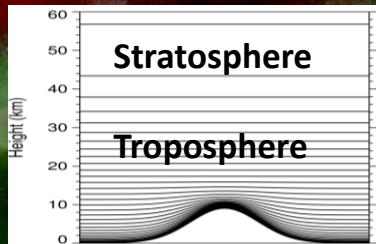
Integrated Dynamics in Earth's Atmosphere (IDEA = WAM+IPE)

- Multi-day forecasts for GPS/GNSS and radio communication customers
- FY15 Deliverable: Execute Real-time run of WAM on NOAA WCOSS
- See Talk by R. Viereck on Friday WAM

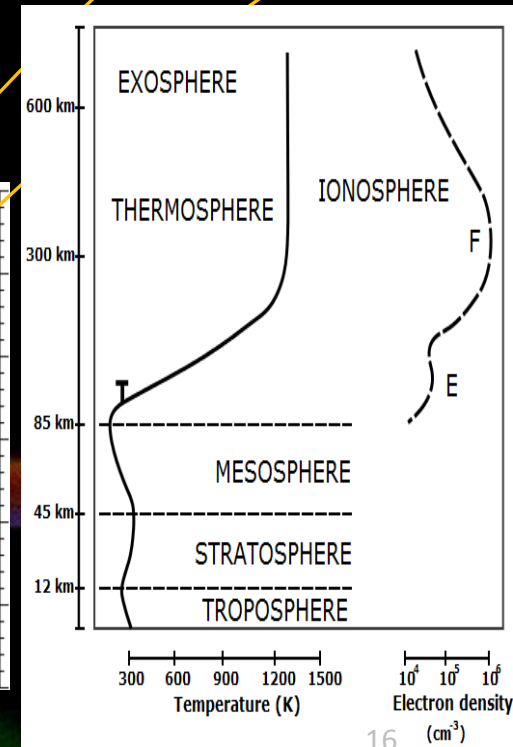
Neutral Atmosphere
0 – 600 km



GFS
0 – 60 km



Ionosphere
Model



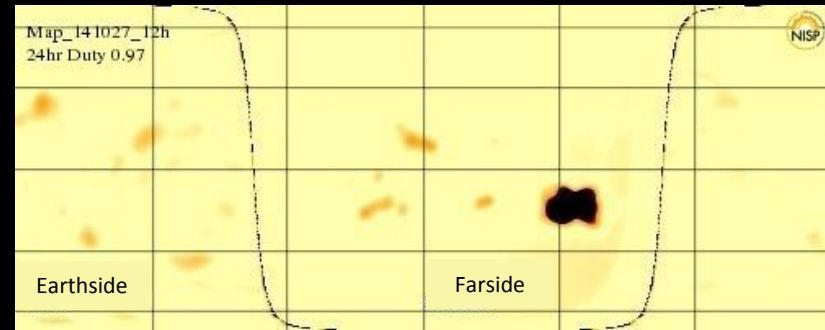
16 April, 2015

Note: SWPC will need to hire several more people to complete the development and transition of this coupled model system into operations.

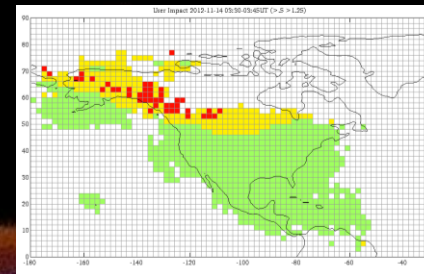
Funding Development and Transition Through SBIR

- One Phase I project(in final selection):
 - Imaging the far side of the sun to improve 1-3 day forecasts.
- Two Phase II project:
 - Developing a GPS product to provide a proxy for ionospheric scintillation (for precision GPS users) based on single frequency observations.
 - Developing improved probabilistic flare forecasts based on new high resolution imagery (from NASA and NSF observations).

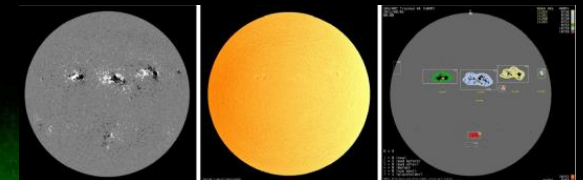
Far-side Analysis
Using Heliosiesmology



ROTI GPS Product



Solar Flare Forecast



Different Procedures for Project Selection and Development

- **Direct Approach:** Select model from the research community based on published works.
 - Pros: Efficient and effective
 - Cons: SWPC does not retain the expertise for O&M. Is not inclusive of the broader research community
- **Democratic Approach:** Hold an open competition between modelers, brokered by a neutral third party (NASA).
 - Pros: Inclusive. Insures the best model gets transitioned
 - Cons: SWPC does not retain the expertise for O&M. Model may be less “operationally ready”.
- **SBIR:** Use the SBIR process to fund development of new models and products.
 - Pros: Development is directed towards operational needs from the start
 - Cons: Only works for smaller models and products
- **Internal Approach:** Develop our own model in-house from the ground up.
 - Pros: Development is closely aligned with SWPC needs. SWPC controls the model and has the expertise to maintain and upgrade
 - Cons: More costly. Takes time.

Recent Accomplishments

- Initial version of the IPE model ready for test and evaluation. Started coupling of IPE to WAM initiated.
- Final selection of the Geospace model (U. Mich.)
 - Research grade model ported to NCEP super computer
 - Contract established with U. Mich to help with transition.
- 3-day aurora forecast test product released for public comment (developed in-house)
- Successful launch of DSCOVR, the NOAA satellite mission to the L1 point between Earth and Sun.
 - Ground processing system is performing very well.

Goals for FY15

- WAM running in real-time on NCEP/WCOSS dev. Computer.
- Geospace model ready for transition (handed over to NCEP/NCO).
- WSA-Enlil (operational model) upgrades implemented
- North American Total Electron Content (expanded US-TEC) model ready to be implemented as a test product
 - Need more high latitude ground-based GPS data
 - SWPC is working on a CRADA with ASTRA to get access to the Alaska region GPS data.
- 3-Day aurora forecast transitioned to operations.
- E-Field specification test product released for public comment.

Bridging the Valley of Death:

Assistance from the Community

- On a path towards a multi-agency Joint Center for Space Weather Modeling
 - There are several examples of multi-agency Joint Centers in the weather forecast community.
 - It has been suggested that a Joint Center for Space Weather Modeling might help the transition process (bridging the valley of death).
 - NOAA and NASA senior leadership are encouraging better cooperation and collaboration between our agencies.
 - The NOAA SWPT and the NASA CCMC are coordinating activities and developing joint tasks to facilitate the R2O process.
 - CCMC and SWPC will collaborate on...
 - Evaluation of models
 - Validation of model performance
 - Test improvements and upgrades to operational models
 - Etc...

Summary

- The SWPT priorities and activities are driven by the needs of the forecasters and customers
- The SWPT is working with several different approaches to selecting and transitioning models
 - Working closely with the research community leveraging the best science to improve products and services
- The SWPT continues to make progress in the R2O process moving forward on several major projects and many smaller ones.